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AN INDUSTRIAL WASTE GUIDE TO THE COTTON TEXTILE INDUSTRY

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an Industrial Waste Guide to the

Cotton Textile Industry

Prepared by the
National Stream Sanitation Committee of the
American Association of Textile Chemists and Colorists
in cooperation with the National Technical
Task Committee on Industrial Wastes

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
BUREAU OF STATE SERVICES
Division of Water Supply and Pollution Control

Foreword

In the Cotton Textile Industry, as in many other industries, the control and disposal of wastes is of major concern. There are two important reasons for increased attention to these problems: first, the need for reducing wastes in order to achieve the most economical production in small as well as large plants; second, the need for protecting the Nation's limited water resources for maximum use essential to health and to continued economic growth. Stream pollution control is mutually beneficial to industry, the individual citizen, and the Nation as a whole. Thus, wastes which cannot be eliminated must be disposed of in a manner which will not impair the usefulness of stream waters for other beneficial purposes.

This *Industrial Waste Guide to the Cotton Textile Industry* is intended primarily to assist the operators and managers of cotton textile processing plants to utilize, reduce, and otherwise suitably dispose of their waste waters. It will also be useful in informing consultants and personnel of regulatory agencies of the sources and pollutional characteristics of cotton textile wastes and the status of developments in waste treatment. This guide was prepared by the National Stream Sanitation Committee of the American Association of Textile Chemists and Colorists, under the direction of R. Hobart Souther. It was submitted for publication to the Public Health Service through the National Technical Task Committee on Industrial Wastes.

The National Technical Task Committee on Industrial Wastes is composed of representatives from the Nation's leading industries concerned with solving difficult industrial waste problems. The objective of the organization is to perform technical tasks pertaining to industrial wastes in cooperation with the Public Health Service and all others concerned with improving the quality of our water resources. The preparation of this guide was one of the tasks assumed by the Textile Industry in carrying out this objective.

This is the fifth of a series of Industrial Waste Guides prepared by the National Technical Task Committee in cooperation with the Public Health Service.

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Cotton Textile Industry

Introduction

The tremendous increase of new industries throughout the Nation has posed an ever-increasing problem to those concerned with water resources with regard to water supply and waste disposal. Industry in general recognizes the importance of the proper use of water; that is, having a plentiful supply of pure water, using it, and returning it to the stream in good condition so that others may use it in turn.

In the early years of this industrial expansion, most liquid process wastes were disposed of into the nearest stream. Little consideration was given to the effect of these wastes on the watercourse. As industrial growth continued and new and different uses of the natural watercourses developed, the amount of pollution in these watercourses increased. This brought about a conflict of interest with those of the riparian owners and resulted in lawsuits. The problems of waste purification or treatment had arrived.

Today, in spite of the great effort which has been expended on the treatment of wastes, the problem of stream pollution is growing and becoming more complex. In some areas of our country, industry, because of its pollution of the water resources, is slowing down its own growth.

The use of a waterway for the disposal of liquid wastes is a legitimate use. However, a definite balance must be maintained between this and the other legitimate uses of the water resource. Because many of these uses are in conflict, the proper balance between these various uses must be worked out for each stream and may even vary for different parts of the same stream. There is a combination of uses which is the best and most economical, because economics must be one of the basic factors in the consideration of multiple use of a stream's waters.

Variability of the character of cotton textile wastes makes this one of the most complex of the industrial wastes problems. No two textile wastes are exactly alike, nor can they be treated in exactly the same manner, although principles can be worked out for each type of waste and applied in similar situations. The combined wastes from different mills are different and are changing constantly as market demand causes process changes. Cotton textile wastes are said to be as varied in character as the kinds and colors of the goods manufactured.

This publication represents the efforts of waste technologists of the Cotton Textile Industry and others to develop a concise, practical guide for the use of operating, engineering, and management personnel of the industry, public health and regulatory officials, and others concerned with the control and alleviation of pollution of the Nation's water resources. Reduction of wastes at their source is the initial objective of waste control programs. Appreciable reduction of waste can be accomplished through waste prevention and good-housekeeping measures carried out within the plant.

With this primary purpose in mind, this booklet summarizes information made available over a period of time by many investigators. Practical methods for carrying out waste-prevention measures within cotton textile processing plants are discussed in some detail.

The liquid wastes from the different cotton-processing operations are described. Considerable emphasis is placed on the many ways in which the volume of liquid wastes requiring treatment can be reduced. These methods include recovery and reuse of chemicals and byproducts, reduction in the quantity of chemicals used in modern methods of process control, reduction of waste flow, substitution of chemicals, process modification, and good-housekeeping practices. Waste prevention and reduction measures produce a double dividend: reduced consumption of supplies and reduced cost of waste treatment.

The section covering the treatment of cotton wet processing wastes is fairly comprehensive. The basic principles for the treatment of the various types of wastes are discussed with examples of solutions to the treatment problems based on cost and/or results.

The bibliography is not a complete listing of all of the literature on cotton textile wastes, but rather a selective compilation of the latest and best published information available on waste utilization and treatment in the Cotton Textile Industry.

Description of Cotton Processing*

The various operations which the cotton fiber goes through in its conversion to the finished fabric are outlined in Figure 1, a flow diagram of a typical integrated cotton textile mill. Many of these processes are dry, producing no liquid wastes. They are, therefore, not described here in detail.

Opening, Cleaning, Carding, and Spinning

The cotton as received in bales is opened and cleaned by machines which blend the cotton as well as remove a great deal of loose dirt. It is then rolled in sheets ready for the carding and spinning operations. The carding operation combs the cotton, aligning the fibers in parallel prior to the spinning into yarn.

Slashing and Weaving

Before the yarn can be woven into fabric it must be strengthened. This operation is called slashing and its purpose is to stiffen the fiber by loading it with starch or other substances called sizing. A small amount of liquid waste may result from this operation. This is usually from the cleaning of slasher boxes, rolls, and makeup kettles, and the leftover size following completion of the run. The sized yarn is then woven into the fabric, brushed, singed, and inspected. The cloth at this stage is called "greige," and may be sold as such. Subsequent operations are all considered as finishing.

Dyeing and Finishing (58)

Preparation of the cloth for dyeing and finishing requires that the size previously added to the yarn be removed. This *desizing* operation provides perhaps the largest single contribution of B.O.D. to the cotton textile waste, as much as 50 percent coming from this source alone. The process is essentially a hydrolysis of the starch size by acid or enzymatic means. In some plants this operation is eliminated, with the size being removed in the boilout or kiering step.

The *boilout* or *kiering* operations vary from one plant to another and also with the type of fabric being processed. The operation consists of cooking the fabric with a hot alkaline detergent or soap solution. This removes not only the cotton wax and other noncellulose materials from the raw cotton, but also dirt, grease, and other foreign matter. Cooking may last from 2 to 10 hours at a temperature up to 250° F. Following this wash the goods are rinsed with hot water and then cold water to remove residual alkali. Wastes from this operation are usually very strong and contain considerable alkali. A *bleaching* step is usually necessary following the boilout. It removes the natural coloring matter of the cotton fiber and is done with chlorine, hypochlorite, or peroxide. Following this operation, the cloth may be rinsed with water and then with an antichlor which is usually sodium bisulfite or, in some cases, a 1-percent solution of sulfuric acid. After this "souring" step, the fabric is again washed thoroughly and may be soaped and tinted to neutralize any retained chemicals and to soften and whiten the fibers.

The dyeing of the goods can be done in a great variety of ways. Details of this operation are beyond the scope of this discussion; however, the various dyeing processes are listed below in order to point out the complexity of this operation and of the resulting wastes. The various types of dyes used are:

Vat—The dye is put on the goods in its reduced state and is then oxidized. These dyes have excellent light and wash fastness.

Developed—The dye is applied to the cloth, diazotized, and the color is developed with a secondary chemical called the developer. These dyes have good wash fastness.

Naphthol—The naphthol is applied to the fabric, passed through the developer for coupling. Produces bright colors, good fastness to light, wash, and bleach.

*References: 19, 32.

Sulfur—The dye is put on the cloth in a reduced state and is then oxidized, producing good fastness to light and washing.

Aniline Black—The aniline is oxidized on the goods by air or steam aging, producing excellent fastness to light.

Basic—Dyes which are used with tannic acid or tartar emetic mordants, producing bright shades, fair fastness, and high tinctorial power.

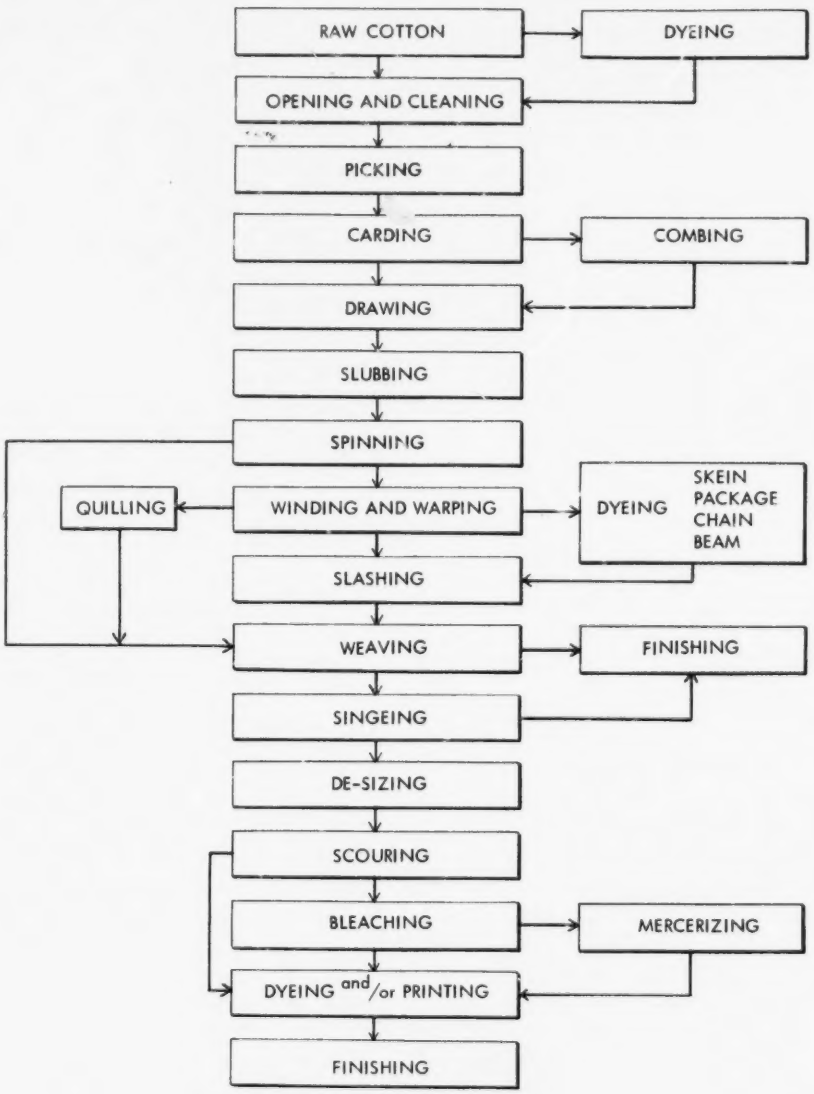
Direct—Apply directly to cloth. These are usually low-cost dyes, easy to apply but not very fast.

Indigo—Similar to vat dyes.

Pigment—Resin bonded to fabric by curing. These are, in general, fast to all agents.

Figure 1

FLOW SHEET—OPERATIONS FROM RAW COTTON TO FINISHED CLOTH



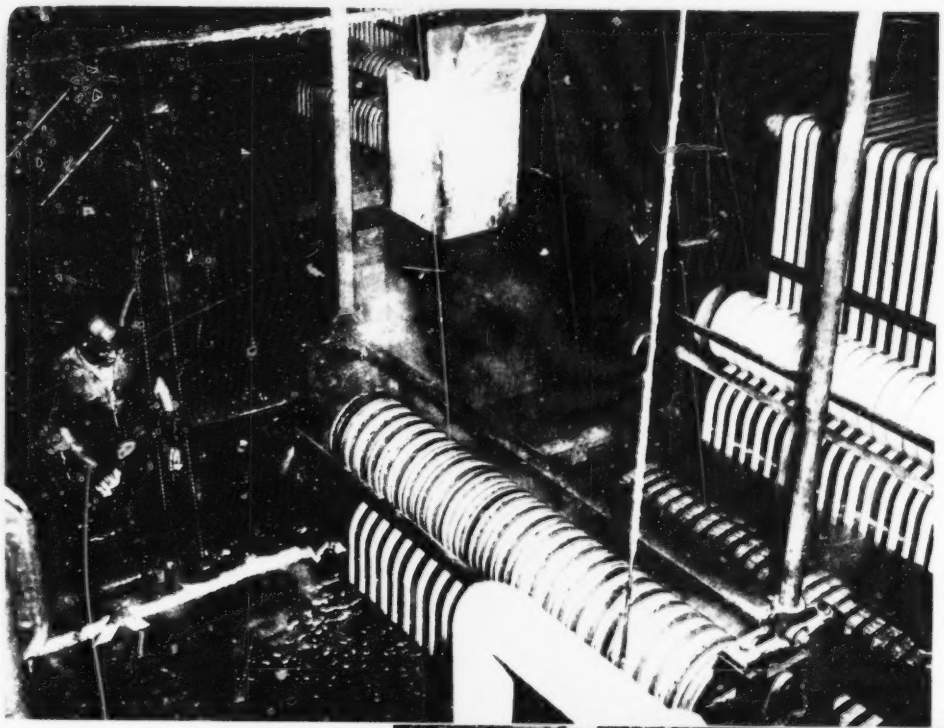


Figure 2.—Continuous chain dyeing of cotton warps with indigo in a large denim mill.

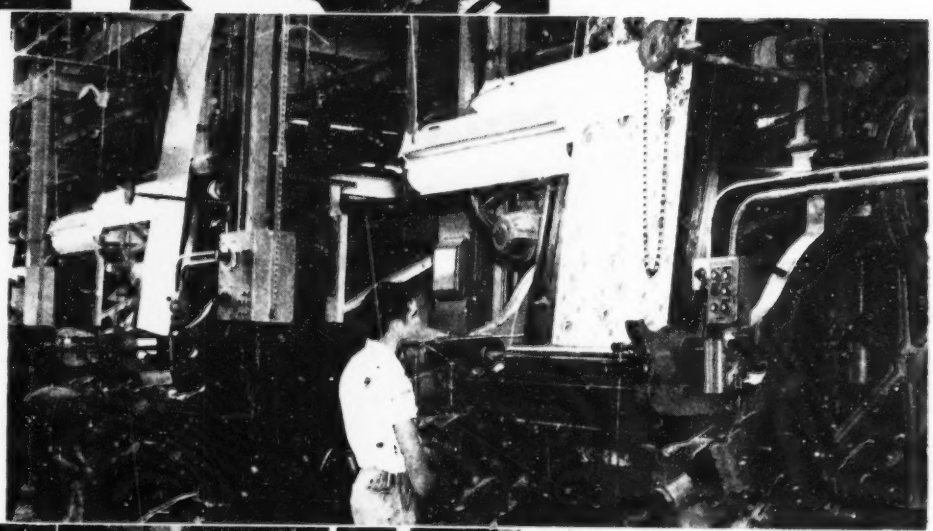


Figure 3.—Printing cloth in a textile finishing plant.

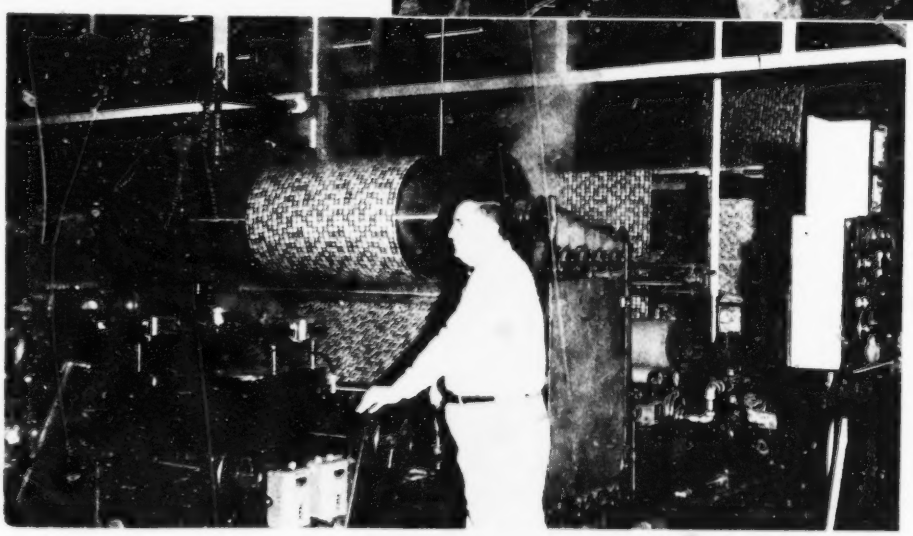
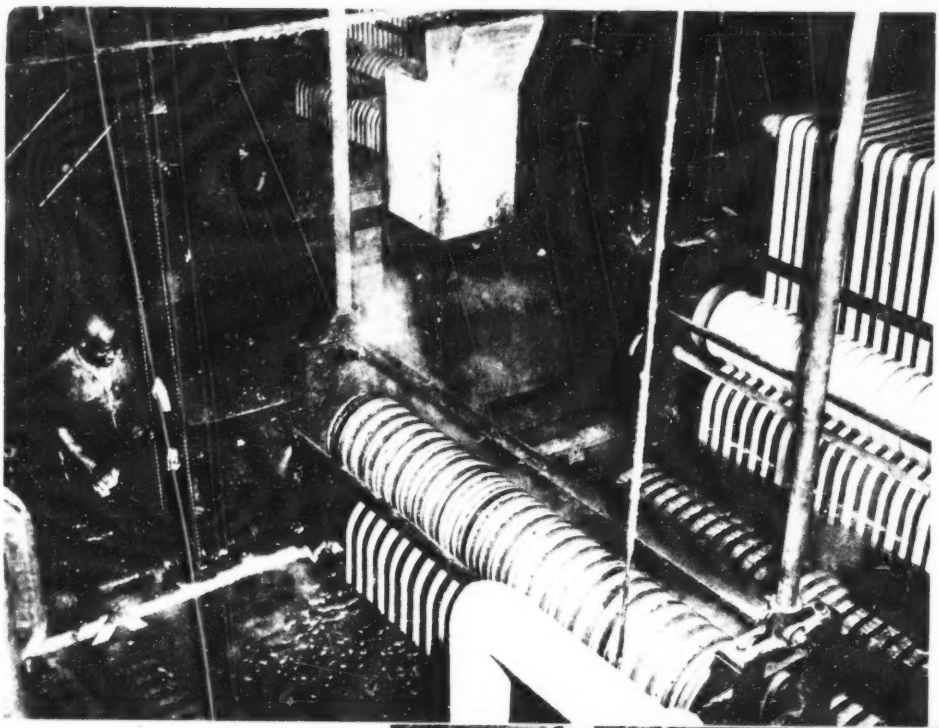


Figure 4.—Sanforizing cloth at a textile finishing plant.



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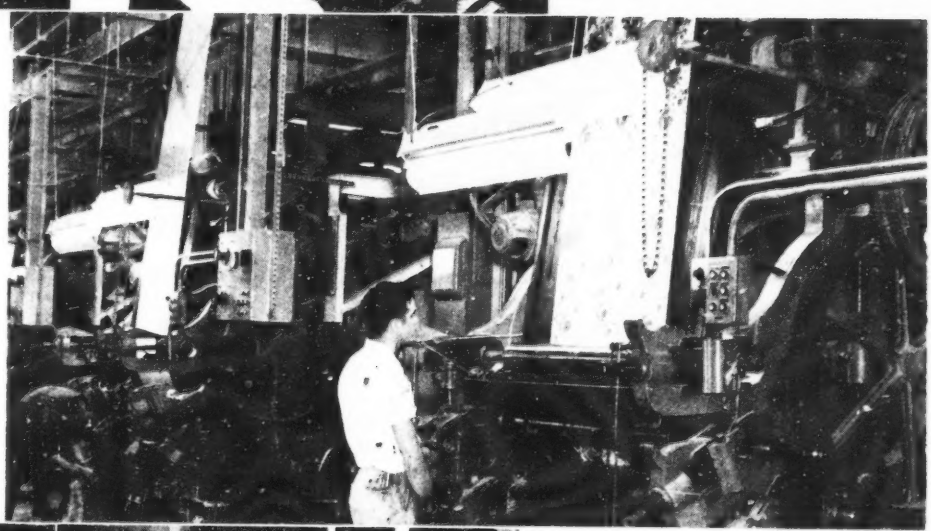

Figure 3.—Printing cloth in a textile finishing plant.

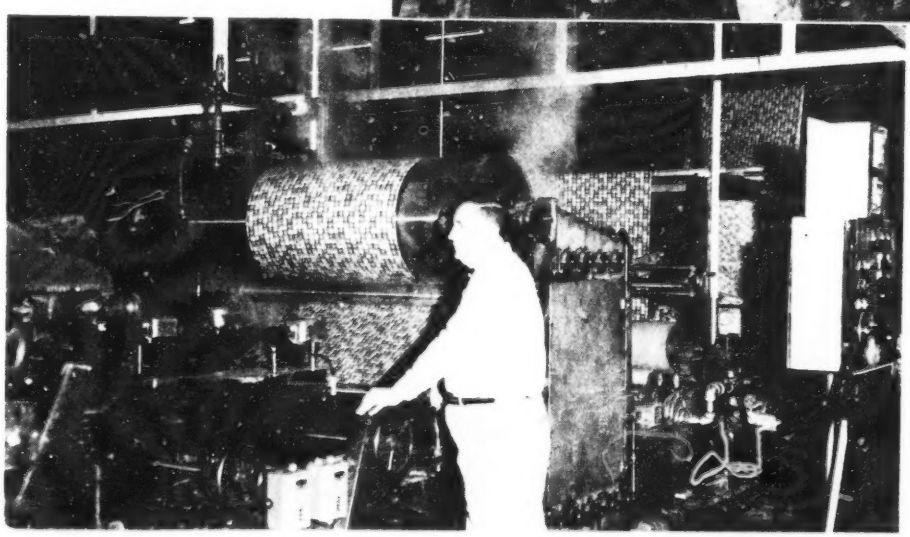

Figure 4.—Sanforizing cloth at a textile finishing plant.

Sources, Characteristics and Pollution Effects of Process Wastes*

The Meaning of "Pollution"

Water is said to be polluted when its character is changed by addition of materials, or in any other manner, in such a way that the usefulness of the water is reduced.

In their natural state, most bodies of surface water and flowing streams are relatively clear and colorless and contain several parts per million of dissolved oxygen which is supplied by absorption from the air and to some extent by plantlife in the water. The dissolved oxygen in the water is as necessary for the existence of fish and many other desirable kinds of life in the water as the oxygen in air is for the existence of man and animals on land. Clarity of the water permits the transmission of light which retards undesirable bacterial growth and generally contributes to a healthy and balanced population of aquatic organisms. Fresh waters in this kind of environment are usually suitable for most uses—as a source of municipal and industrial water supplies, for recreational bathing and fishing, irrigation, etc.

Pollution represents any undesirable departure from the condition described above. It can occur naturally as well as artificially. The most common form of natural pollution occurs when rains wash dirt from uncovered ground and when heavy streamflows stir up the stream bottom. The stream is thus polluted by muddying, which may destroy animal and plantlife on the bottom, reduce fish populations, and render the water less suitable for many beneficial uses. Improper land-use practices of man contribute greatly to this form of pollution. Another source of natural pollution is the leaching of excessive quantities of salts or harmful materials from the formations over and through which the water flows. The alkali waters of the Southwest are examples of this type of pollution.

Manmade pollution results chiefly from the discharge of wastes from cities and industries. Domestic wastes are relatively uniform in composition and in their effect on streams. Methods of treating municipal sewage are fairly standard; therefore, wastes from the plant's sanitary facilities can usually be discharged to public sewers without special concern to the plant operator.

In contrast, industrial wastes vary widely in character and in their polluting effects; therefore, each type of waste is a special waste treatment problem.

Most organic substances undergo a more or less gradual chemical or biological change which takes dissolved oxygen from the water. The extent of oxygen depletion depends on the rate of this oxygen demand in relation to the reaeration characteristics of the stream. If the dissolved oxygen is reduced below certain limits, desirable fish and aquatic life cannot exist. Complete removal of dissolved oxygen from a stream results in a septic condition characterized by obnoxious odors, floating solids, and a generally disagreeable appearance. Suspended organic solids may deposit on the bottom of quiet areas in the stream, concentrating the oxygen demand of these wastes in those areas. Waters containing considerable organic material are generally unsuitable for municipal and industrial water sources, and for recreational and some agricultural uses.

The introduction of disease organisms or harmful bacteria into the stream is another form of pollution which is particularly harmful to uses such as drinking water sources, recreation, and bathing. Sewage is the principal cause of this type of pollution.

Excessive concentration of soluble inorganic salts generally renders water unsuitable for industrial and municipal water sources. Concentrations of sodium and boron salts above certain limits cannot be tolerated in irrigation water. A serious disadvantage of this type of pollution is that soluble inorganic salts are not usually removed by natural stream purification processes; therefore they may affect use of the water far downstream from the point of entry. Acids and alkalies react to form salts and, in addition, have corrosive effects on boats and structures in contact with the water.

A number of substances are toxic to fish and aquatic life. Many of the metals which may be present as salts fall into this category. The acids, alkalies, and numerous members of other classes of compounds may have similar effects. Some substances are toxic to humans also if present in sufficient concentration in water supplies.

*References: 3, 4, 11, 12, 23.

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The pollution may be in the form of the addition of tastes, odors, and color to the water. Phenol is an example of a pollutant which results in serious taste problems in drinking water supplies. Color in itself is esthetically objectionable, particularly in drinking and recreational waters. Some industrial process waters must also be free of color.

Suspended, inert matter may also have detrimental effects on the utility of the stream. It makes the water turbid, reduces light penetration, and much of it eventually settles on the bottom. The turbidity increases the cost of treatment required for municipal and industrial uses. Deposits on the bottom may harm bottom-dwelling aquatic life, reduce the carrying capacity of the stream channel, and shorten the useful life of reservoirs. There are instances in which the deposition of industrial wastes has increased the dredging necessary to maintain ship channels.

Listed below are some of the principal polluting effects of certain types of materials frequently present in industrial wastes.

Polluting agent (59)	*Effect*
1. Acids, alkalies, and inorganic salts.	Toxic to fish and aquatic organisms. Deteriorate boats and structures in the water. Detrimental to municipal, industrial, and irrigation uses.
2. Dyes	Add color which is esthetically objectionable in drinking and recreational waters.
3. Inert matter, such as pigment, clay, coal dust, etc.	Adds turbidity, settles on stream bottom. Reduces desirable fish population. Increases municipal and industrial water treatment costs. Interferes with navigation and may reduce useful life of reservoirs.
4. Organic matter, including organic oils, greases, and salts.	Depletes dissolved oxygen, eliminating desirable fish populations. May add tastes, odors, and turbidity detrimental to industrial and municipal water supplies. Forms floating scums esthetically objectionable and harmful to recreational uses such as bathing.

The liquid wastes in the cotton processing industry originate, except for slasher wastes, in the dyeing and finishing operations. The chemical properties of these wastes are summarized in table I.

TABLE I.—*Typical examples of cotton processing waste properties* (15) (39)

Wastes	pH	Alkalinity (p.p.m.)				B.O.D. p.p.m.	TS p.p.m.
		Total	CO_3	HCO_3	OH		
Slasher waste (Cone Mills Laboratory Research):							
Strong (1)	9.2	1,040	248	800	0	37,700	76,976
(Directly from machine) (2)	8.9	660	0	660	0	36,000	77,247
Weak (1)	7.2	34	0	34	0	1,800	4,078
(Washings from kettles, etc.) (2)	8.4	52	12	40	0	1,885	3,308
Desizing waste: Starch size	7.2	202	0	202	0	5,130	23,000
Kiering waste:							
Pressure kier	13.1	20,240	1,860	0	18,480	1,840	26,740
Open kier:							
First boil	10.0	10,000	7,800	2,200	0	3,750	19,642
Second boil	9.8	7,400	5,800	1,600	0	2,280	16,064
Continuous boiloff	13.1	20,400	6,600	0	13,800	5,750	39,605
Hot rinse	11.8	265	90	175	0	63	366
Bleaching wastes:							
Chlorine	9.5	310	90	220	0	119	2,310
Peroxide	9.6	1,265	560	705	0	1,200	9,040
Mercerizing waste	12.1	9,282	275	0	9,007	15	10,398
Rinse	9.6	125	110	0	15	52	641
Dyeing waste:							
Aniline black		38	0	38	0	46	831
Basic	6.3	65	0	65	0	167	628
Developed	6.9					200	8,140
Direct	7.5	81	0	81	0	337	9,400
Indigo alkaline wash	11.9	2,700	1,910	790	0	2,080	5,834
Indigo wash	11.25	2,200	1,400	800	0	928	1,132
Naphthol	9.5	1,310	1,084	0	226	108	8,475
Sulfur bath	10.5	4,200	3,600	600	0	3,000	36,980
Vat	9.6	714	660	0	54	129	1,770
Color shop wash wastes	9.0	193	0	193	0	133	2,880
Finishing (Cone Mills Laboratory Research):							
Strong (from machine)	8.8	490	65	425	0	13,600	41,646
Weak (washing)	7.1	37	0	37	0	680	2,050

Slasher Wastes

Slasher wastes consist principally of starch and a softener, originating from the washup of starch kettles, slasher machines, floor scrapings, and the leftover size material after completion of operations. It is a very strong waste but of low volume. Numerous investigators have suggested the substitution of carboxymethylcellulose (CMC) for the starch in order to reduce the B.O.D. level, and some mills have already made this change. Polyvinyl acetate is another substance which has been suggested as a substitute for starch.

Desizing Wastes (32)

Desizing wastes are highly organic in character, being composed mainly of the breakdown products of the starch size and the agent used to effect the hydrolysis. In this operation, the sized cloth is run through the desizer solution and then into boxes where it remains moist for several hours while the desizing agent is reacting. It is then washed, thus removing the hydrolyzed products from the cloth. Although the volume of this waste is relatively low, its B.O.D. contribution to the total waste load may be as high as 50 percent.

Kier Wastes

Kier wastes result from the boiling of the "greige" fabric in preparation for the bleaching and dyeing operation. These wastes are fairly high in organic matter and are strongly alkaline. They contain natural vegetable fat, waxes and pectin, solid fragments from the cotton ball, starch or other sizing material which was not removed in the desizer, and caustic soda, soda ash, silicate, and small amounts of other chemicals used in the kier bath. Kiering practice varies from a light kiering or "wet-out" to a double caustic "boilout." The more rigorous this operation, the greater the quantity of impurities removed (23). The fabric is rinsed several times following the boil and the total volume and strength of the kier waste depends on the thoroughness of this rinse. Up to 30 percent of the total B.O.D. load is contributed by this operation.

Bleaching Wastes

The bleaching operation usually follows the cleaning or deterging process described above. Chlorine, hypochlorite, and peroxide bleaches are widely used in the cotton industries. The wastes from the chlorine and hypochlorite processes are similar in characteristics, being strongly alkaline, and containing partially spent bleaching agents and the organic matter removed from the cotton. Contribution of such waste to the total B.O.D. load may be as high as 10 percent. Peroxide bleaching may be done in the kiering operation or applied separately in a second kiering. The souring and rinsing operations, using sodium bisulfite or weak sulfuric acid, follow the bleach step (32).

Mercerizing Wastes

Mercerizing wastes contribute only a small pollution load since the caustic in this process is reused and the only wastes are due to the rinsing out and neutralization of the excess caustic.

Dyeing Wastes

The largest volume of waste from the textile-finishing plant comes from the dyeing operations. The wastes from these operations are varied because of the different types of dye used and the manner in which they are applied. The dye wastes are all large in volume, high in color, and some may be toxic. The B.O.D. of these wastes is generally low, but may be as high as 37 percent of the total load in some mills. The chemicals used in this process run the gamut of the chemists' handbook. Considerable immediate oxygen demand may be present in these wastes because of the reducing agents used in some of the dye baths.

Miscellaneous Wastes

Miscellaneous wastes from the color-printing and finishing machines are usually low in volume and occur principally from the cleanup operations on the machines and kettle washings. The materials used in these operations are expensive and a close watch is kept to prevent excessive wastage. Materials such as starch, dye, gums, waxes, and resins are the principal polluting materials in these wastes.

Composite Wastes

A composite of the wastes from an integrated cotton textile processing plant consists mainly of the following materials: starch, dextrin, gums, glucose, waxes, pectins, alcohols, acetic acid, soap, detergents, sodium hydroxide, carbonate, sulfate, and chloride. The pH varies between 8 and 11, it has a grayish colloidal turbidity, the color is that of the predominant dye used, it has a total solids content from 1,000 to 1,600 p.p.m., a B.O.D. of 200–600 p.p.m., total alkalinity of 300–900 p.p.m., suspended solids of 30–50 p.p.m., and chromium up to 3 p.p.m. Its volume is usually considerable, ranging between 30,000 and 93,000 gallons per

1,000 yards of finished goods. Needless to say, this quantity of waste produces a considerable pollutional effect on the stream into which it is discharged.

Table II is a compilation of the range in characteristics of cotton processing wastes in relation to the quantity of goods processed.

TABLE II.—*Pollution effect of cotton processing wastes (composite of all wastes connected with each process)*

Process	Wastes (p.p.m.)			Gallons wastes per 1,000 lbs. goods	Pounds B.O.D. per 1,000 lbs. goods	Pounds total solids per 1,000 lbs. goods	Population equivalent per 1,000 lbs. goods
	pH	B.O.D.	Total solids				
Slashing, sizing yarn*	7. 0–9. 5	620–2, 500	8, 500–22, 600	60–940	0. 5–5. 0	47–67	2–30
Desizing		1,700–5, 200	16, 000–32, 000	300–1, 100	14. 8–16. 1	66–70	90–100
Kiering	10–13	680–2900	7, 600–17, 400	310–1, 700	1. 5–17. 5	19–47	10–105
Scouring		50–110		2, 300–5, 100	1. 36–3. 02		8–18
Bleaching (range)	8. 5–9. 6	90–1, 700	2, 300–14, 400	300–14, 900	5. 0–14. 8	38–290	30–90
Mercerizing	5. 5–9. 5	45–65	600–1, 900	27, 900–36, 950	10. 5–13. 5	185–450	60–80
Dyeing:							
Aniline black		40–55	600–1, 200	15, 000–23, 000	5–10	100–200	40–60
Basic	6–7. 5	100–200	500–800	18, 000–36, 000	15–50	150–250	100–400
Developed colors	5–10	75–200	2, 900–8, 200	8, 900–25, 000	15–20	325–650	90–120
Direct	6. 5–7. 6	220–600	2, 200–14, 000	1, 700–6, 400	1. 3–11. 7	25–250	25–75
Indigo	5–10	90–1, 700	1, 100–9, 500	600–6, 000	1. 8–9. 5	21–63	10–60
Naphthol	5–10	15–675	4, 500–10, 700	2, 300–16, 800	2–15	200–650	13–80
Sulfur	8–10	11–1, 800	4, 200–14, 100	2, 900–25, 600	2–250	300–1, 200	14–1, 500
Vats	5–10	125–1, 500	1, 700–7, 400	1, 000–20, 000	12–30	150–250	75–175

*Cloth weaving mill waste.

Remedial Measures*

In the preceding sections, the operations of a typical cotton textile mill were described and the liquid wastes resulting from these operations were discussed and characterized as to their pollutional effects. The subsequent discussion will attempt to point out the areas where waste prevention and reduction measures can be applied and the means whereby the ultimate treatment of wastes can be affected. The primary objectives are twofold: to return used water to its source in as clean a condition as possible, and to achieve this at the least cost consistent with the first objective.

Waste reduction, prevention, and utilization measures, if carried out conscientiously, will provide twofold dividends. By reduction in waste load, the plant operator reduces the volume and quantity of supplies wasted. In so doing, the cost of treating wastes which cannot be further controlled is reduced, thus accomplishing a saving in the cost of supplies and also in the cost of treatment. Many times, the saving resulting from these operations is more than enough to pay for the cost of the waste treatment.

*References: 7, 51.

Inplant Reduction of Processing Wastes

In the following paragraphs are discussed some of the ways in which the waste load of a processing plant may be reduced. First is the question of reduction of waste volume. Each plant should study the following questions: Can process waters be reused? Can counterflow box waters be reused? Can weak wastes be segregated from the other plant effluents for direct disposal without treatment?

Reduction of Waste Volume

Process waters can frequently be used as makeup for subsequent operations. It is possible that the stronger rinse waters from a dyeing operation may be used to make up a new dye bath. The "strong washes" from mercerizing may be used to make up "kier" and "wet-out" baths. The last, "weak" rinses from several operations might be recycled through the plant's water treatment operations (23).

Some processes can utilize a counterflow procedure.

In a typical layout, the liquid proceeds from tank to vat in the opposite direction to the movement of fabric. The process is set up so that fresh liquid first contacts the fabric containing the least soluble or reactive matter. It then proceeds to material containing greater quantities of reactive matter, and ultimately is discharged, or used for bath makeup, after contacting fabric with the heaviest load of waste. This procedure has been used successfully in aniline black dyeing, in bleaching, and in the washes following indigo dyeing (23).

In some cases, segregation of weak wastes from strong wastes has advantages. By separation and disposal of weak wastes directly, without treatment, the plant gains considerably by reducing the volume of the waste which needs treatment, thus reducing the size of the treatment plant required and the handling costs for large volumes of water. This may be difficult to accomplish in some of the older plants because of the costs of piping changes, etc.; however, if the pollution standards of the receiving stream are not exceeded, and the volume and characteristics of these weak process waters is known, disposal by this method should be of great advantage, economically (5).

Reduction of Process Chemicals (30)

Second, how can the use of process chemicals be reduced? Studies of processes can be made with the aim of reducing the overall quantity of process chemicals which are ultimately wasted. One example is the Cone-Mill method (18). This method of controlling dyeing by measurement of the reduction potential of the bath prevents the waste of excess chemicals used in the dyeing operation (48). In bleaching and kiering it is important that the treatment of the fabric be uniform in order to produce a uniform color and finish. Continuous treatment of the material produces less offshade cloth and less liquid wastes, thus reducing both the cost of production and the cost of waste treatment. The application of counterflow washing, systematic control of bleach baths, recirculation of wash waters, reuse of dye baths, and other conservation measures based on modern control methods will ultimately result in economy.

Recovery and Reuse of Chemicals (23)

Recovery and reuse of chemicals and byproducts, if it can result in savings, is a third possibility. In recent years, considerable progress has been made in the recovery of caustic soda. Most cotton textile plants try to reuse this as many times as possible, especially in mercerizing, plisse printing, and in certain cases, open boiling and other cleansing operations. However, in some of the processes, the caustic may either be too diluted or too contaminated with impurities to make reuse practical. In many bleacheries, over 70 percent of the caustic which goes to waste could be recovered economically. The crux of the problem is efficient washing of the fabric. Residual caustic in the cotton must be very low to ensure quality, and efficient washing removes the maximum amount of caustic with the minimum amount of water. Sometimes by efficient washing, the residual caustic content of the wash waters may be high enough for reuse without further treatment. In the majority of the bleacheries a considerable volume of caustic waste liquor remains even after every effort has been made to reuse it. If there is available annually as much as 400 tons of sodium hydroxide at a minimum strength of 2 percent, its recovery by evaporation for reuse may be economically feasible.

As caustic soda solutions are reused, impurity loads will build up. Some of these may precipitate out on cooling and this may be sufficient purification. However, if quality of cloth is affected by impure caustic, the solution can be purified by dialysis. In this operation, the concentrated caustic solution is first filtered to remove insoluble solids, then dialyzed to remove the soluble impurities (52). Recovery of caustic from mercerizing waste and wash waters can also be done by centrifuging and evaporation. At low concentrations, most of the hemicellulose and other impurities are removed by the centrifuge. The concentrated mercerizing bath is also purified by mixing it with the dilute liquors and centrifuging. This procedure does not achieve the same degree of purification as dialysis, but does have the advantage that the impurities at low concentrations are removed without further dilution (23).

Valuable heat may be recovered from hot waste discharges through heat exchangers. By simply installing copper piping in the waste lines, some mills have heated the water used in the dyehouse (23).

Efforts have been made to recover dyes and accessory chemicals. Recovery by absorption on fuller's earth and activated bauxite followed by solvent extraction has been attempted (55). Thus far, such efforts have not been particularly successful or profitable.

Process Modification

A fourth way to achieve waste reduction is by process modification. Reduction in the volume of liquid dye waste from raw stock sulfur dyeing has been real-

ized by changing the method of dyeing. The usual method was to dump the bath after each dyeing, losing much valuable material down the drain. The process was changed to the standing-bath type of dyeing, wherein the dye bath is pumped out to a storage tank and saved for reuse in the makeup of the next bath, thus reducing the pollution load from this operation and also saving a considerable quantity of makeup chemicals (51).

Sometimes the manufacturer of the dyestuff can assist in the problem. One process achieved a 30- to 50-percent reduction in the discharge of sulfides to waste through a modification in the manufacture of the dyestuff itself (48).

Substitution of Chemicals (31)

One great area for exploration in the reduction of waste loads is the substitution of chemicals with low pollution effects for those with high pollution effects. Many studies have been made in recent years on the substitution of CMC for starch in the slasher (sizing) operation. Up to half of the total pollution load can be eliminated by this inplant substitution. Replacement of acetic acid by a mineral acid in the various dyeing processes reduced the total pollution load of one plant by 22 percent, and of another plant, 10–15 percent (10). Replacement of soap by synthetic detergents has cut the pollution load at some plants by 50 percent. It can be readily seen that by the simple substitution of low pollution chemicals for ones with high pollution effect, the waste treatment requirements of many plants can be greatly reduced. The table below compares the B.O.D. values of several finishing compounds and serves to emphasize the reduction which may be achieved by substitution of chemicals.

TABLE III (10, 54).—*Comparison of B.O.D. values exerted by certain finishing chemicals*

	B.O.D. of 1,000 p.p.m. solution
Corn starch, acid modified	477
CMC	9
Methyl cellulose	1.6
Polystyrene (stymer)	12
Polyvinyl alcohol (80.5 percent hydrolysis)	16
British gum	690

Good Housekeeping

The last, but by no means least important, step in pollution reduction from plant operation is the practice of good housekeeping. A day-to-day routine of good housekeeping, close control of operations to avoid accidental spilling of dye baths, storage tanks, etc., saves money and also avoids pollution. Preparation of too large a batch of solution results in waste when the excess cannot be used or stored and must be disposed of. Good housekeeping practices must be a cooperative effort between management, plant personnel, and maintenance crews. This cooperation must include education as to the benefits of the program, especially for the operating personnel. A plant can be designed and engineered for minimum loss through spillage, breakage, etc., but if the operating personnel do not cooperate or do not understand the reason for these practices, these efforts may be lost. Good housekeeping is, therefore, an essential part of any effort by the plant to reduce its pollution load (51).

*Treatment of Processing Wastes**

After all the possibilities of reducing the waste strength and volume have been exhausted, there still remains a considerable quantity of waste water which is highly pollutional in character and which must be disposed of without adverse effects on the receiving stream. This waste water must be subjected to treatment in order to reduce its pollutional effect to a level which can be tolerated by the stream and also permit its use for other legitimate purposes. There are many methods available for the treatment of cotton textile waste waters. Some of these methods may be used to advantage for certain portions of the plant's wastes, while others are more generally applicable to the combined wastes. The best combination of methods for waste treatment will differ from plant to plant; consequently, every plant must evaluate these procedures in the light of its own operations. A brief description of the various treatment methods is given below.

Separation of Wastes

Waste treatment problems can often be reduced by the separation of individual process wastes and their separate treatment. The factors which govern this within the plant are complex and their importance

*References: 1, 6, 9, 13, 14, 16, 21, 24, 25, 26, 27, 29, 38, 45, 53, 56.

varies among the various plants. The decision to segregate wastes depends, along with other considerations, on—

a. The character of the individual waste and the treatment requirements of the receiving stream.
b. Cost of inplant changes such as separate sewers, piping, etc.
c. Benefits which may be gained if, by segregation, a large volume of weak effluent can be discharged with little or no treatment.
d. Design requirements to eliminate human factors, which could result in inadvertent mixing of wastes to be segregated.

Equalization and Storage (36)

The extreme variation in flows and characteristics of textile wastes makes equalization of flow a basic requirement for the first step of any treatment method. Treatment processes operate best under conditions of constant flow and constant waste composition. The use of equalization tanks or storage lagoons provides a means whereby the greatest efficiency in waste treatment can be attained. The size of these tanks or ponds will depend on the treatment process used and the capacity and method of operation of the mill. In plants where a large and variable flow of wastes occurs, the equalization tank serves to level out the volume and composition before the treatment process is reached. In some installations alternating tanks are used, one for treatment of the previous 24-hour flow, the other for collection of the current waste flow. This practice eliminates the possibility of any untreated waste being released to the receiving stream.

Large storage ponds, sometimes classified as "lagoons," are constructed to take advantage of some waste purification which may occur when a large volume of waste is so contained. Lagoons are usually constructed large enough to provide the following treatment: They serve to equalize flow and pollution load; they provide cooling for high temperature waste waters; they allow time for sedimentation of the larger solid waste particles; and some pollution reduction takes place because of biological action resulting in reduction of B.O.D. and color. Proper maintenance is necessary to avoid objectionable odors.

Lagoons are a cheap and useful means for partially treating wastes which can be subsequently diluted by discharge into large waterways. Occasionally they are used for post treatment or "polishing" of the waste effluent following other treatment processes.

Screening, Mechanical Filtration (23)

Screening is a necessary adjunct to the treatment of most wastes because large particulate matter, if not removed, would cause clogging of sewers and interference in the subsequent treatment processes.

Mechanical filtration has been used to treat the various types of textile wastes either after chemical precipitation or after the addition of absorbent materials to remove color. It is essentially a straining action and should only be used on a highly polluting waste as a secondary treatment. Types of filters used are: coke or coke ash beds, coal beds, rock beds, sand filters, pressure filters, etc. An objection to this type of treatment is that filter media tend to clog and must be cleaned frequently. The principal uses of these filters are in conjunction with the other treatment methods. Their purpose is to "polish" the effluent. In that sense they have been successful, as the resulting final effluents have a high degree of clarity. Effluents with B.O.D. of less than 10 parts per million, no turbidity, and very low color have been obtained. In some experiments, filter aids such as powdered coal, wood dust, or sawdust have been tried. The resulting sludge or scum could be disposed of by burning.

Aeration

Aeration, in the sense discussed here, is not connected with biological oxidation, but is considered as a combination of both physical and chemical treatment. It is accomplished either by diffusion of air under the surface of the wastes, or by spraying or cascading of the waste water. Its purpose is to provide oxygen to the waste in order to prevent anaerobic decomposition, to chemically oxidize easily oxidizable organic and inorganic matter, and to control odor-producing gases. In practically all cases, aeration is useful in conjunction with other treatment methods, either as a pretreatment or as a final effluent polish.

Neutralization (28)

The neutralization of waste water is usually a prelude to some other phase of treatment, although some effluents may be discharged merely by adjustment of pH to the limits required for the receiving stream. Equalization tanks are sometimes valuable in accomplishing this. Neutralization, or pH adjustment, is necessary when the waste to be treated is either too acid or too alkaline for proper biological treatment.

It was once believed that successful biological treatment would not result unless all wastes were neutralized

to a pH of 7.0. More recent experience has indicated that the upper limit for pH is between 8.5 and 9.5, with values above this range resulting in considerable loss in efficiency of the treatment process. However, with certain wastes, biological treatment above pH 9.5 has been found feasible under certain conditions. To illustrate: Activated sludge treatment operates best at pH values between 7.0 and 9.0. A 5- to 15-percent loss in efficiency occurs at pH's up to 9.5; 10- to 30-percent loss will occur up to pH 10.0; and 30- to 50-percent loss between 10.0 and 10.3. Trickling filters are not as sensitive to pH. Best results may be obtained between 7.0 and 9.5 with acceptable results up to 11.5, if hydroxide alkalinity is relatively low. The governing factor in this treatment seems to be the amount of hydroxide alkalinity and not the pH. Thus, the biological treatment processes available can operate successfully at high alkalinities, depending on the process and on the type of waste, and reducing the chemical costs of neutralization.

Chemical Precipitation (17, 22, 47)

The treatment usually recommended in the past for cotton textile wastes has been chemical precipitation. This method, whether in combination with lagooning or as the only treatment, if carefully controlled, has consistently produced good results. (The operator should bear in mind, however, that plant changes may produce changes in waste characteristics which, in turn, may require variations in the standard treatment procedures for effective control.) The one drawback to this method is the cost of chemicals required.

Plant facilities required for chemical precipitation of wastes include the following: equalization basin, rapid mix basin, settling tanks or lagoons, chemical feeders and feed control devices, mixers, pH meters and recording instruments, sludge-handling equipment, and chemical storage facilities. The chemicals most frequently used are alum, copperas, calcium chloride, lime, chlorine, sulfuric acid, and combinations of these. Points of addition for the various chemicals vary. The metallic coagulants should be added to the rapid mix basin. Acids for pH control should enter at the rapid mix basin or ahead of it. Lime for pH control may enter either ahead of or after rapid mixing. Floc formation is speeded up when lime is added ahead of the coagulant. Lime added after copperas produces a heavier floc; also, its addition after the coagulant improves B.O.D. and color removal (57).

A partial list of chemicals used, current costs, and results obtained on various cotton textile wastes is included in tables IV and V.

TABLE IV.—*Chemical treatment of cotton textile wastes*

(Cost of treatment of individual wastes as reported in the literature)

Dye wastes	Chemical used (number per 1,000 gal.)		Cost (cents per 1,000 gal.)	Percent color reduction	Reference
(1) Aniline black wash water	(1) Alum	0.9	2.6	84.0	(39)
	Lime	.4			
	(2) Copperas	2.3	3.6	80.0	
	Lime	.6			
(2) Developed dye waste composite: Dye vat, diamotized vat, developed vat.	(1) Copperas	11.6	17.3	85.0	(39)
	Lime	2.1			
	(2) Ferric sulfate	18.3	48.5	65.0	
	Lime	10.5			
(3) Direct dye waste	(1) Ferric sulfate	2.8	5.9	75.0	(39)
(4) Indigo waste liquor	(1) Lime	7.0	6.7	65.0	(51)
	(2) Copperas	5.8	17.7	94.5	
	Lime	12.5			
(5) Naphthol waste mixture: Naphthol, caustic, oil, dye bath.	(1) Sulfuric acid	21.8	20.2	99.0	(39)
(6) Sulfur dye waste	(1) Sulfuric acid	36.5	33.4	99.0	(51)
	(2) Alum	58.0	141.0	99.0	
(7) Vat dye waste	(1) Copperas	92.8	134.0	85.0	(39)
	Lime	12.5			
(8) Kier waste	(1) Alum	83.7	200.0	99.5	(51)
	(2) Copperas	145.0	204.0	98.0	
	Lime	12.6			

TABLE V.—*Chemical treatment of mixed waste*

Wastes	Chemicals used (number per 1,000 gal.)		Cost (Cents per 1,000 gal.)	Percent removal		Reference
				B.O.D.	Color	
Sulfur and indigo dye	(1) Copperas	5. 85	13. 4	41. 5	91. 0	(51)
	Lime	5. 85				
	(2) Alum	20. 9	57. 0	43. 7	97. 5	
	Acid	6. 5				
Kier, finishing, dyeing, color shop, mercerizing.	(1) Copperas	4. 2	5. 5	18. 9	0	(51)
	(2) $CaCl_2$	5. 0	9. 3	49. 5	60. 0	
	(3) Copperas	6. 2	10. 12	41. 2	30. 0	
	Lime	2. 2				
	(1) Copperas	4. 2	5. 5	20. 0	50. 9	(51)
	(2) Copperas	5. 8	14. 2	59. 5	83. 5	
	Lime	5. 8				
	(3) $CaCl_2$	8. 4	15. 5	47. 5	83. 0	
Dyeing and finishing	(1) Copperas	5. 85	7. 75	42. 4	80. 0	(51)
	(2) Copperas	4. 2	9. 55	52. 5	80. 0	
	Lime	4. 2				
Mixed dye waste: Vats, sulfur, direct developed, etc.	(1) Cl_2	4. 5	20. 2	30–40	90. 0	(51)

Chemical Oxidation

Wastes which contain reducing agents or compounds which are easily oxidized by oxygen should not be permitted to enter the receiving stream without treatment. This type of waste produces an immediate or very rapid depletion of the dissolved oxygen in the river, bringing about nuisance conditions and a marked reduction in the capacity of the stream for assimilation of biologically active wastes. Wastes which can be readily oxidized by aeration or by chlorine should be segregated and pretreated by this means before mixing with the plant wastes for further treatment. Aeration will drive off odors, oxidize these compounds producing an immediate oxygen demand, and in general "freshen up" the waste, making it more readily treatable by biological processes. Chlorine, on the other hand, reacts immediately with most odor-producing substances and with much of the organic material, reduces the bacteria content of the waste, and produces an effluent in which the rate of biological oxidation is retarded. In general, chemical oxidation with chlorine is used in conjunction with some other treatment method, either as a pretreatment or as a post or "polishing" treatment for the waste effluent.

Biological Oxidation

The organic matter present in the cotton textile wastes, if discharged into the receiving stream, provides a food source for the many micro-organisms present in the water. These organisms, acting on the waste, rapidly multiply, utilizing the dissolved oxygen of the stream, reducing its concentration, and producing an environment unfavorable to fish and other freshwater biota. Excessive pollution by organic and other oxygen-consuming compounds produces septic conditions resulting in odors, floating scum, sludge banks, and other indications of gross pollution. The removal of this organic load from waste effluents is carried out by one of several biological methods available which utilize natural processes for rapid oxidation of the organic wastes and produce a satisfactory stabilized effluent suitable for final disposal to the receiving waters. Cotton textile wastes free from toxic substances treat more easily than sewage, because of high content of nitrogen, phosphates, and starch and other nutrients.

The *Trickling Filter Process* (43) utilizes a bed of stones or other hard media over which are sprayed the wastes to be treated. This simulates the purification process of a stream, flowing over a rocky bed. The stone provides a base for the anchoring of the biological growths which, in the presence of air freely circulating in the filter, attack the organic matter of the waste, using it for food and thus removing a large fraction of it from the waste water. As these organisms multiply, they break off from the stones and settle out in the settling tank which follows the trickling filter. The resulting effluent is usually clear and can be discharged with or without a final polish directly into the receiving stream. The sludge from the settling tank is combined with sludge from the primary settling tanks and is disposed of by methods to be described under sludge disposal. These filters provide as much as 90 to 95 percent reduction in B.O.D.,

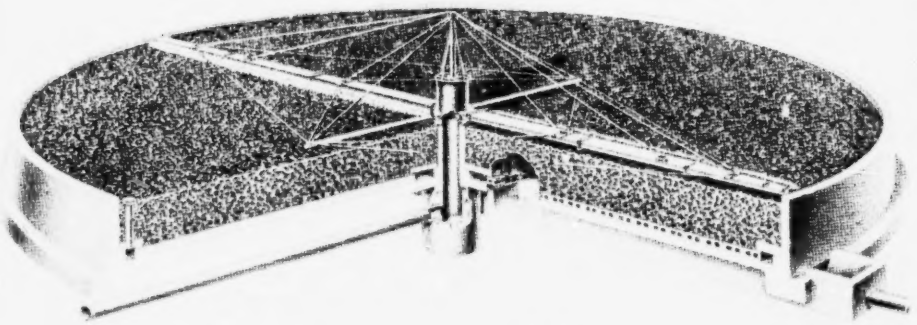

Figure 5.—Detail of trickling filter construction. The aerobic bacteria living in the slime coating on the stones "digests" the organic matter remaining in the wastes coming from the clarifier.

depending on the type of waste and the total waste load. They are less affected by changes in waste characteristics than is the activated sludge process. Their principal disadvantages are the cost of installation and the space requirements. A filter occupying 1 acre of space can treat 10 million to 30 million gallons of waste per day. So-called high-rate trickling filters recirculate some of the treated effluent and this results in more efficient operation of the treatment process (49).

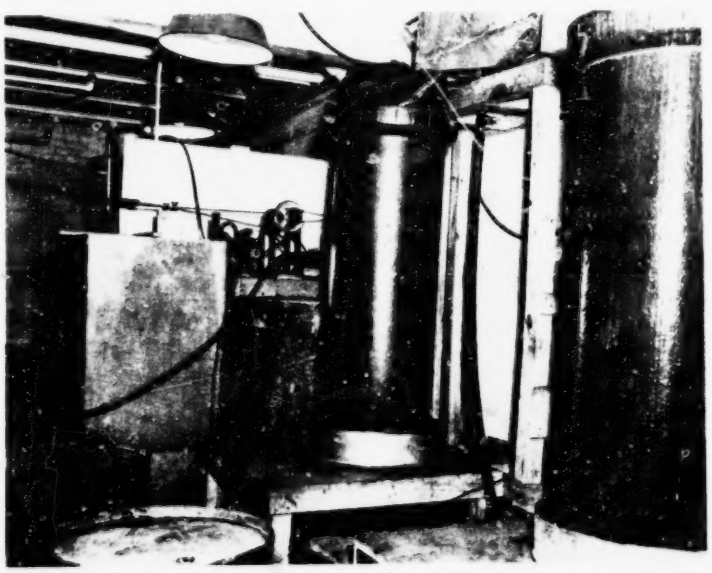

Figure 6.—Laboratory pilot plant trickling filter studies at a cotton mill.

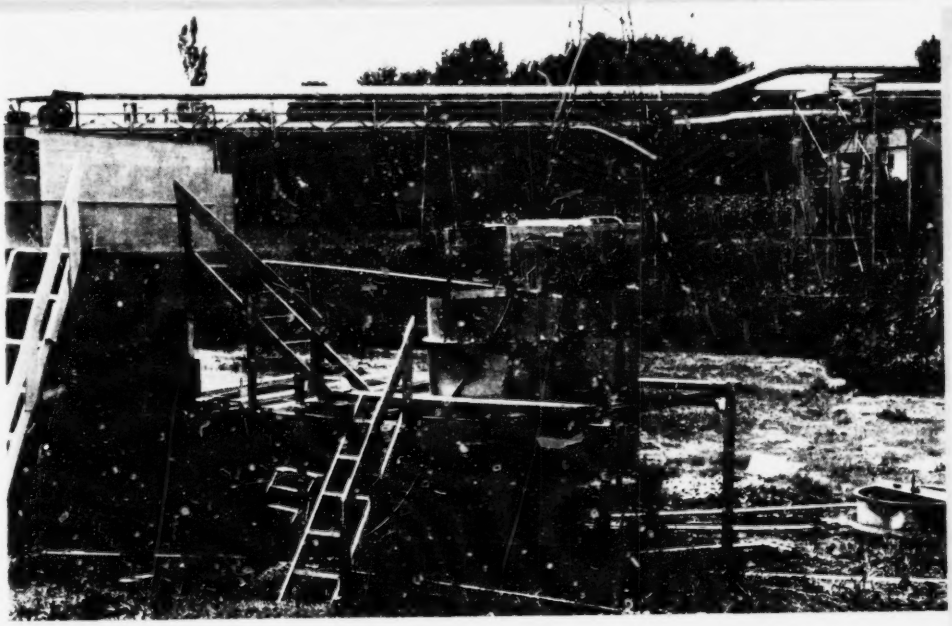

Figure 7.—Larger scale pilot plant studies in treatment of mill waste and sewage through high-rate trickling filters.

The Activated Sludge Process (40, 41, 42) provides no fixed medium comparable to the stones of the trickling filter. Instead, the micro-organisms are suspended in the waste, forming a gelatinous aggregate which is flocculent and settles rapidly. This material is kept in suspension by compressed air or in the presence of air by mechanical mixing. The air supplies the oxygen necessary for biological activity. The process is kept self-perpetuating by withdrawing and settling the mixture and recycling a portion of this biologically active sludge to mix with the incoming waste. This treatment results in a clear, stable efflu-

Figure 8.—Pilot plant activated sludge treatment of combined mill waste and sewage at a textile mill laboratory.

ent and in overall reduction in B.O.D. up to 90 to 95 percent, depending on the type of waste and the total waste load. It is perhaps the most efficient process for reducing the organic waste load of an effluent. However, it is more sensitive than the trickling filter to changes in waste characteristics, and requires more rigid pH control and waste equalization. Its advantages lie in less space requirements and a lower installation cost. Sludge disposal, as with the trickling filter, must be provided (44). The Biosorption Process has been found to be less subject to upsets and more economical for treating textile waste-sewage mixtures than conventional processes.

Contact aeration is a variation of the activated sludge process whereby the organisms are attached to closely spaced vertical plates submerged in the aeration tank.

Endogenous respiration is a process whereby the waste, after seeding with biologically active sludge, is aerated until the organic matter of the waste is totally oxidized to carbon dioxide, thus eliminating the need for sludge disposal. The process works automatically in that the waste is pumped from a storage pond and flows through slowly. The aeration period may be as long as several days (2).

The oxidation pond, perhaps the cheapest method for reduction of organic load, is a shallow pond through which the waste is allowed to flow slowly with up to 30 days' retention time. The active organisms are maintained by oxygen from the air and by oxygen produced through the activity of algae. In oxidation ponds, as distinguished from storage ponds, the waste must be kept aerobic either by controlling the depth or by partial recirculation of the pond effluent. These ponds work best in warm, sunny climates. The advantages of the oxidation pond are low construction cost, low maintenance cost, and simplicity of operation. Aeration lagoons provide economy in smaller space requirements.

Figure 9.—Lagooning or storage of mill waste at a finishing plant.

Sludge Disposal

In most of the physical, chemical, and biological treatment methods described, the process of waste water purification produces a considerable quantity of sludge, or solid matter, which must be removed from the process and disposed of. Sludge from chemical precipitation can be dewatered, dried, and buried or used as a land fill. Sludge from the biological processes and from primary settling tanks is highly organic and requires some further treatment to render it suitable for disposal. It is usually digested under anaerobic conditions, producing a low-grade fuel gas. The digested sludge can be used as a humus. Other methods of disposal are aeration, drying, and incineration, or production of a low-grade fertilizer.

Disposal to Municipal Sewage Treatment Systems

The most economical method for complete treatment of textile mill waste is to combine it with domestic sewage where practical, utilizing either a trickling filter, or an activated sludge process, or a combination of both. This combined treatment can give a lower overall cost than the separate treatment of domestic sewage and textile waste. In detail, it reduces capital outlay, provides more economical operation, places the treatment under skilled supervision, provides nutrients from the sewage for the textile wastes, provides dilution for the textile waste, and requires the operation of one treatment plant rather than two. Mixtures of textile waste and domestic sewage with pH's ranging as high as 11.5 have been satisfactorily treated through high-rate trickling filter-activated sludge units (50).

The textile plant should strive to reduce the amount of necessary treatment by the municipal plant through the reduction of water consumption, substitutions of low for high B.O.D. chemicals, caustic soda recovery, more economical use of chemicals, modern methods of control, recovery and reuse of chemicals, and process modification. (The purpose is to eliminate shock loads on the treatment plant.) All of these have been discussed in some detail earlier in this guide.

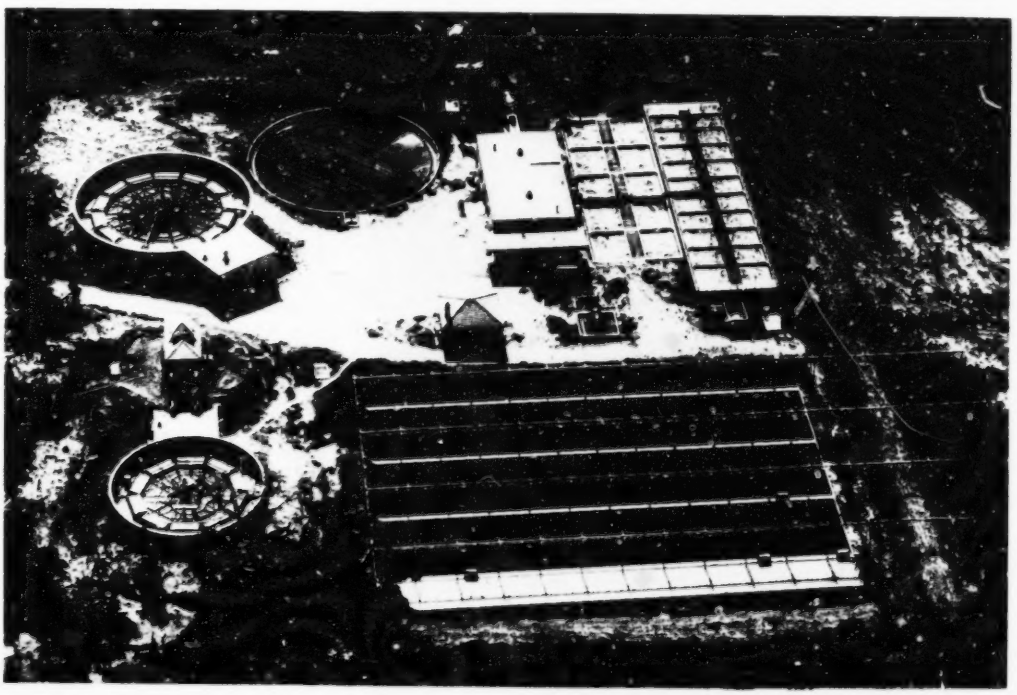

Figure 10.—A typical bio-activation plant, showing trickling filters and activated sludge units.

The type and amount of treatment necessary for the combined waste depends on local conditions, the size of the waterway, other industry on the waterway, uses of this waterway, etc. In general, the larger the waterway used for ultimate disposal, the less the degree of treatment that is necessary.

In cases where the treatment plant already exists and the textile waste is to be added for treatment (the majority of cases fall into this category), the need for enlarged facilities will depend on the type and amount of waste. In general, if the plant is an activated-sludge type, addition of filters ahead of the aeration units is the best method of enlarging the capacity. In other cases, such as trickling filter plants, it is advisable to add extra filters, or sometimes, chemical precipitation. So much depends on the local conditions that it is difficult to make blanket statements.

Current operations in plants designed from recent research confirm findings that combined treatment of mill waste and sewage is both feasible and practical, and also most economical. (8)

The Solution of Specific Waste Problems (5)

In the preceding section, the methods for treatment of wastes were discussed. The usefulness as well as the limitations of these methods were pointed out, including some of the benefits and costs of each process. It was also recognized that although the wastes from cotton textile mills have similar characteristics, each plant should consider its waste as unique and should study its own problems before entering into a waste treatment program. Therefore, this section will be concerned with how each plant can determine what its specific waste problems are and how it can solve its own waste treatment problems to best adavntage.

Before a plant begins to institute a waste treatment program, it must define the magnitude of the problem. The following determinations and actions must be taken:

1. What is the volume of the wastes
   (*a*) before waste reduction measures have been taken?
   (*b*) after waste reduction measures have been taken?
2. What volume of waste requires treatment?
3. Will separation or segregation result in a material reduction of the waste volume requiring treatment?
4. Wastes must be analyzed to determine the ranges in strength and pollutional characteristics of each waste and of the combined wastes.
5. What effect will future expansion plans have on the volume and pollution load of those wastes requiring treatment?
6. Each waste should be evaluated from the standpoint of toxicity. Can the waste effluent be tolerated by the biological processes of treatment?

Having satisfactorily determined the magnitude of the problem, the first step toward solution is to initiate methods for the reduction of wastes and waste volumes as outlined in the section on "Inplant Reduction of Processing Wastes." Inplant changes such as improved process control, process modification, substitution of process chemicals, recovery and reuse of chemicals and byproducts, reduction in waste flow, and institution of good-housekeeping practices should be evaluated to determine what savings can be made. Those which result in substantial reduction in pollution load should be instituted.

Next, a study should be made of the maximum waste load which can be imposed upon the receiving stream consistent with the stream standards set up by the regional regulatory agency. This will determine how much treatment will be required to condition the waste prior to discharge. Frequently, it will be found that only a minimum of treatment will be necessary to meet the stream standards if adequate attention has been given to the inplant waste-reduction program.

If, after every effort has been made to reduce the pollution load, the waste remaining still requires extensive treatment, the question of combined treatment with municipal sewage should be considered. In general, if the waste is compatible with the sewage treatment process of the municipality, disposal through the municipal system will often be less expensive than treat-

ment by the industry. This method, however, brings questions of its own which must be resolved, such as:

1. What is the maximum ratio of mill waste to sewage which the city plant can treat satisfactorily?
2. Is the city plant of adequate size to handle the added load?
3. What effect, if any, will the plant waste have on sewer lines?
4. What pretreatment will be necessary to render the plant waste compatible with the city sewage?
5. What are the overall costs and benefits of joint treatment as against separate treatment by the industry?

Every effort should be made to utilize city treatment facilities for the disposal of plant wastes. In doing so, the plant management is relieved of the responsibility for maintaining an additional control over another process; the stream regulatory agency is relieved of the necessity for surveillance of another treatment plant; and the responsibility for proper treatment and disposal of the plant wastes is assumed by the municipality which is usually staffed by personnel competent to cope with the problems of treatment plant operation.

Finally, when the only alternative is for the industry to carry out its own treatment operations, a study must be made as to the method which will give the best and most economical treatment to the plant wastes. Since information has been compiled as to how much treatment is necessary to meet the stream standards, the question to be answered is how to do it for the least expense. The first step toward solution of this problem is a thorough literature search. In many cases, solutions to similar problems have already been reported and it is only a matter of selection of the best of the reported methods. However, if information is not available, a laboratory and pilot plant investigation should be made preliminary to any determination (50). The treatment methods outlined previously should all be considered. Certainly, if the plant has sufficient land area, the oxidation pond should not be overlooked as a means of treatment. In any event, laboratory and pilot plant studies will invariably result in a better understanding of the individual plant's problems and will usually point out the direction to the most economical treatment process.

Studies should be made on the segregated as well as the combined wastes. By preliminary chemical treatment, some wastes may be discharged directly without further treatment. Biological treatment processes should be investigated to determine their effective range for the wastes to be treated. In any event, a choice of a treatment method should not be made without pilot-plant experimentation.

Figure 11.—A modern cotton finishing plant.

Summary

This industrial waste guide is an attempt to cover one of the more complex waste problems—cotton-processing wastes. The magnitude and scope of this problem, the different wastes to be expected, the pollutional characteristics of these wastes, methods of reducing the volume and pollution load, and various treatment methods available, have been discussed.

Selected sources of information on cotton-processing wastes have been tabulated. Also, a series of steps showing the procedure for finding the best solution to a particular waste treatment problem is listed.

The fact that waste prevention and reduction measures are the most important means of eliminating a waste disposal problem cannot be emphasized too strongly.

Any progress in reduction of waste volume or pollution load made through prevention and reduction measures is money saved, because the smaller the volume and pollution load of the final waste, the more economical the final treatment.

This guide is not intended to be the last word in the solution of all textile waste problems. Research is continually striving to provide newer and better ways for waste treatment. The Textile Industry, like all modern industries, is changing as new fibers and new processes are developed. What is an adequate solution of a waste problem today may be outmoded tomorrow by advances in textile processing or by better treatment methods. One very important factor always to bear in mind is that while industrial expansion is continuing in this country at a record rate, the water resources of the Nation are limited. As more industrial water uses develop, industry must learn to conserve the available water supply, use it to full advantage but return it to the stream in a condition suitable for other legitimate water uses. Thus, this guide attempts to point the way toward a solution to the waste treatment problems of the Cotton Textile Industry and to provide information and examples which will enable the industry to find solutions to its own problems.

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